“The Middle of it All”
Regional Interdependence and the Thoracic Spine

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Learn how to see. Realize that everything connects to everything else.

Leonardo da Vinci
Let’s begin with a story….

- Limited research of the thoracic spine ‘Cinderella’ region
- Thoracic dysfunction is under-explored
- Thoracic spine manipulation is beneficial for managing neck and shoulder pain
- Thoracic spine may be viewed as a ‘silent contributor’ to clinical presentations
- Further research of thoracic spine pain and dysfunction is needed
Objectives

1. To present the Regional Interdependence Model (RIM) – research evidence, mechanisms and clinical implications as it relates to the thoracic spine and upper quadrant dysfunctions.

2. To illustrate the integration of the concepts with a case history presentation.

3. To outline a clinical reasoning framework considering the biopsychosocial framework and evidence-informed practice.


Why is the thoracic spine a special region for manual therapy?

- Relatively stiff region compared to cervical and lumbar
- 6 synovial joints per vertebral level – CV, CT & ZPJ
- Presence of sympathetic chain anterolaterally
- Relatively narrower vertebral canal for spinal cord and dura
- Abundance of segmental muscles (rotatores, levatores costarum) with perhaps proprioceptive vs movement function
- Protective function – lungs and heart
- Life sustaining function – breathing

Management of thoracic pain and dysfunction: a survey of current practice in the UK

(Heneghan NR et al 2018 with permission pending publication)

EXAMINATION: Active ROM testing, palpation and postural assessment was ‘always’ done by > 89% of respondents, with 94%, 81% and 76% always examining the thoracic spine in cervical, shoulder and lumbar spine complaints respectively.
Management of thoracic pain and dysfunction: a survey of current practice in the UK
(Heneghan NR et al 2018 with permission pending publication)

**TREATMENT:** Thoracic spine interventions were used in the management of: cervical spine (89%), shoulder (82%), lumbar spine (63%) and elbow (17%).

Active and passive techniques were used by >85% of respondents, with approximately 50% using manipulation techniques, taping and acupuncture.

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Manipulative Practice in the Thoracic Spine: a survey of current practice of Physiotherapists in the UK
(Davies S, Puentdura EO, Heneghan NJ JMMT 2018)

- Survey of 276 physios in the UK (53% males) – mean age 36 (8.7) yrs - mean years in practice 11 (8.1)
- Only 40% used any additional screening before using TJM to the thoracic spine
- Preferred choice was prone manipulation (67%)
- Most consider underlying effect of TJM to be:
  - neurophysiological (54%)
  - biomechanical (45%), and
  - placebo (1%)
- Very high levels of agreement for stated contraindications (85%); precautions (75%); red flags (86%) and risks (61%)
Regional Interdependence Model

(Wainner 2007, Suecki 2013, McDevitt 2015)

Regional Interdependence Model

Musculoskeletal

Somatovisceral

Biopsychosocial

Neurophysiological

Regional Interdependence

(Suecki et al 2013)
Mechanisms of Manual Therapy

Mechanisms of Manual Therapy

Peripheral Mechanisms

Spinal Cord Mechanisms

Supraspinal Mechanisms

Preferences
Expectations
Pain beliefs
Pain-associated distress
Prior experience

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Thoracic Manual (neuromusculoskeletal) Therapy and Neck Pain

Interventions: Neck Pain with Mobility Deficits

Acute
For patients with acute neck pain with mobility deficits:

B Clinicians should provide thoracic manipulation, a program of neck ROM exercises, and scapulothoracic and upper extremity strengthening to enhance program adherence.

C Clinicians may provide cervical manipulation and/or mobilization.

Subacute
For patients with subacute neck pain with mobility deficits:

B Clinicians should provide neck and shoulder girdle endurance exercises.

C Clinicians may provide thoracic manipulation and cervical manipulation and/or mobilization.

Chronic
For patients with chronic neck pain with mobility deficits:

B Clinicians should provide a multimodal approach of the following:
- Thoracic manipulation and cervical manipulation or mobilization
- Mixed exercise for cervical/scapulothoracic regions: neuromuscular exercise (eg, coordination, proprioception, and postural training), stretching, strengthening, endurance training, aerobic conditioning, and cognitive affective elements
- Dry needling, laser, or intermittent mechanical/manual friction

C Clinicians may provide neck, shoulder girdle, and trunk endurance exercise approaches and patient education and counseling strategies that promote an active lifestyle and address cognitive and affective factors.
The middle of it all Regional Interdependence and the Thoracic Spine

13 RCTs included – 7 were of high quality (PEDro)

3 studies on treatment of shoulder conditions – little evidence to support

9 studies on treatment of neck conditions – sufficient evidence to support

Pooled estimator (1.33) statistically significant for treatment effect of TSM with researcher effect removed (95% CI: 1.15 – 1.52)

“There is sufficient evidence to support the use of TSM for specific subgroups of patients with neck conditions.”

At short-term and intermediate-term follow-up, multiple sessions of thoracic manipulation were favoured for pain reduction among participants with acute/subacute neck pain, and for functional improvement among those with acute to chronic neck pain. No additional pain relief was reported when thoracic mobilisation was used.
Acute / Subacute Neck Pain

MODERATE EVIDENCE in favour of:
- Manipulation at the involved cervical level combined with exercise when compared to manipulation to the thoracic spine combined with exercise
- Manipulation thoracic plus cervical accessory mobilization combined with exercise compared to cervical accessory mobilization with exercise
- Manipulation to the upper thoracic combined with electro/thermal-therapy in comparison to electro/thermal-therapy alone, for pain relief and functional improvement in the very short-term
- Combined manipulation and mobilization to the cervical and thoracic or home exercise in comparison to usual medical care for pain and satisfaction with care from short to long-term

Chronic Neck Pain

MODERATE to STRONG evidence:
- In favour of manipulation and manipulation/mobilization on cervical and thoracic spine with exercise in comparison to exercise or manual therapy alone for pain, function, satisfaction with care and general-health from short to moderate-terms.

MODERATE evidence:
- In favour of mobilizations using soft-tissue-techniques to the cervical and thoracic spine or combined mobilizations/manipulation to the cervical and thoracic spine in comparison to no-treatment in the short-term for pain and disability.
Clinical Prediction Rule (Cleland et al 2006)

- Recent onset (<30 days)
- Low FABQ (<11)
- No symptoms distal to the shoulder
- Looking up does NOT aggravate symptoms
- Cervical extension <30
- Flat T3-T5

Pre-test Probability of Dramatic Success with Manipulation: 54%
Post-test Probability of Dramatic Success with Manipulation: 86%

+LR = 5.5

Evidence – Randomized Controlled Trials (RCTs)

CONCLUSION: The results of this validation study did not support the validity of the previously developed CPR. However, the results demonstrated that patients with mechanical neck pain who received thoracic spine manipulation and exercise exhibited significantly greater improvements in disability at both the short- and long-term follow-up periods and in pain at the 1-week follow-up compared with patients who received exercise only.

https://www-ncbi-nlm-nih-gov.proxy1.lib.uwo.ca/pubmed/20634268
CONCLUSION: Individuals with neck pain who received a combination of thoracic spine thrust manipulation and cervical spine non-thrust manipulation plus exercise demonstrated better overall short-term outcomes on the numeric pain rating scale, the Neck Disability Index, and the global rating of change.

https://www-ncbi-nlm-nih-gov.proxy1.lib.uwo.ca/pubmed/23221367
Cervicogenic Headache (Dunning et al 2016)

**CONCLUSION:** Patients with CGH who received cervical and thoracic manipulation experienced significantly greater reductions in headache intensity, disability, headache frequency, headache duration, and medication intake as compared to the group that received mobilization and exercise; the effects were maintained at 3 months follow-up.

CONCLUSION: The findings from this RCT suggest that both NTM and TM produce comparable outcomes on pain, disability, and motor performance for patients with mechanical neck pain when applied in a pragmatic fashion. Patients’ perceived level of change, the number of visits, and the duration of care were similar between groups.
Manual Therapy Techniques – Thoracic Spine

Limited evidence to suggest which thoracic technique is the most effective.

Manual Therapy Techniques – Thoracic Spine

- A supine thrust targeted to the most hypomobile thoracic segment was shown to have a greater effect on decreasing immediate pain and increasing cervical range of motion than a seated distraction technique applied with no specific target. (Karas et al 2014)

- Specific manipulation of the thoracic spine had positive effects on neck outcomes, the direction of thrust applied to the identified hypomobile motion segment did not make a significant difference on the measured outcomes in subjects with neck pain. (Karas et al 2018)
Thoracic Manual (neuromusculoskeletal) Therapy and Shoulder Dysfunction
Thoracic Spine Posture and shoulder pain, range of motion and function

There is a strong level of evidence that maximum shoulder ROM is greater in erect postures compared to slouched postures (p<0.001), in people with shoulder and without shoulder pain.

Clinical implications: examine whether the patient's symptoms are immediately modifiable by altering the thoracic kyphosis (Symptom Modification Model)


Biomechanics – Arm Elevation thru Flexion

Scapula: upward rotation
posterior tilt and external rotation
looking for “dyskinesis”

Clavicle: elevation, retraction & posterior rotation

Humerus: maintained centered humeral head
during flexion and slight ER at GH joint

Thorax & lower cervical spine:
rotation to ipsilateral side of elevation
at end range, no rotations or shifts
through range, some extension at end-range

(With permission from Diane Lee 2018)
Arm Elevation

- The thoracic spine forms a key link in the kinematic sequence of arm elevation.
- Scapular or humeral range will evoke compensatory movement in the spine.
- It is important, therefore, that assessment of the upper quadrant includes the assessment of the thoracic spine.

Thoracic Manual Therapy and Shoulder Pain

Treatment to the Thoracic Spine
- may biomechanically restore the $15^\circ$ of thoracic extension required to achieve full shoulder elevation
- improve the recruitment of muscles in the shoulder girdle
- have a neurophysiological effect on pain and function

Pain and dysfunction of the first and second ribs and the cervothoracic junction were identified in 40% of 101 individuals with non specific shoulder pain (NSSP) compared to asymptomatic individuals. (Sobel JS et al 1996)
Clinical implications of this review is that it is likely that clinicians can use thoracic manual therapy to accelerate recovery, in terms of pain reduction and reduced disability immediately and for up to 52 weeks compared with usual care for NSSP.

It may be achieved without directly treating the glenohumeral joint, which may be preferred with a highly irritable presentation.

Clinical Prediction Rule (Mintken et al 2010)

1. Pain-free shoulder flexion < 127 degrees
2. Shoulder internal rotation < 53 degrees at 90 degrees of abduction
3. Negative Neer Test
4. Not taking medication for shoulder pain
5. Symptoms less than 90 days

Pre-test Probability of Dramatic Success with Manipulation: 61%
Post-test Probability of Dramatic Success with Manipulation: 89%

+LR = 5.3
THE EFFECTIVENESS OF THORACIC MANIPULATION IN MANAGING SHOULDER DYSFUNCTION - A Systematic Review

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TABLE 2. Summary of RT PEDRO Scores

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CONCLUSION: Thoracic spine manipulation should be considered in the management of pain, mobility and functional limitations for adults with shoulder dysfunction.

Effects of Thoracic Manipulation on Neurodynamic Mobility

- Increases in neurodynamic mobility (ULTT and Slump Test) occurred following thoracic mobilization or manipulation
- May impact the sympathetic chain ganglion
- Adverse neurodynamic mobility and mechanical hypomobility of the thoracic spine and rib cage could be related to widespread somatic musculoskeletal complaints (Hartstein AJ et al 2017)
Evidence / Limitations

- Immediate and short term effects of thoracic manual therapy for neck and shoulder dysfunction are highly supported by numerous articles.
- Long term effects are not yet supported by the evidence.
- Multimodal approach – combination with exercise and education is recommended.
- Prescriptive versus pragmatic trials, n of 1 clinical trials.
- Minimal empirical evidence on exercise prescription in the thoracic spine (Heneghan NR et al 2018).

Evolution

Biomechanical / Patho-anatomical model

Multidimensional, Neurophysiologically based Assessment and Treatment Interventions
Evidence-Informed Practice

In the absence of research evidence how do we support our assessment and treatment strategies?

“The advantage of a clinical reasoning approach is that it is responsive to new knowledge and evidence, is flexible and allows for change and growth.” (Gwen Jull IFOMPT 2012)

Biopsychosocial Framework (Jull 2017)
Clinical Approach

Classification System

Evidence-informed treatment approach

Key Features in Patient History

Formulate your Physical Examination

Search for Evidence
CPGs, CPRs, Systematic Reviews, Case Studies

Toolbox

Treatment evidence

Classification Systems

Clinical Prediction Rules CPRs

Assessment evidence

Clinical Practice Guidelines CPGs

Clinical Experience

Patient Preferences

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Case Presentation - History

- Ms K is a 25 year old newly graduated physiotherapist presenting with a 2 year history of neck, left shoulder, scapular and thoracic spine pain
- Reported some episodes of radiating pain into the left medial elbow with occasional paraesthesia into the 4th and 5th fingers
- She felt that her symptoms were aggravated by prolonged periods of studying over the past 2 years and were provoked with practical labs
- She also complained of lack of upper body strength and found it difficult to train at the gym as any exercises targeted to upper quadrant would aggravate her symptoms
- Previous history – she had sustained a ‘whiplash/concussion’ injury after an offensive header during a high level competitive soccer game
- She denied any recent injury, just that “she felt tired and tight”

Behaviour of Symptoms

- **P₁**: neuro symptoms - left medial elbow pain with occasional paraesthesia into the 4th and 5th fingers. NPRS at rest 0/10; 4/10 when wearing a heavy back pack, holding something heavy in that hand, lifting weights at the gym
- **P₂**: intermittent upper trapezius and suboccipital pain, more often ‘tight’ on the right, provoked by prolonged positions (studying). NPRS 3/10 and can go as high as 6/10 and may trigger a right sided headache. Relieved by postural correction and change of position. There are times this bothered her more in the last year than the arm pain; had 2 episodes of spasm (always around exams or with rapid arm elevation).
Behaviour of Symptoms

• **P₃**: left sided thoracic/scapular stiffness more so than pain NPRS 1/10, provoked with certain movements (left rotation and extension); aggravated this fall after she started mobility/scapular strengthening exercises at the gym.

Outcome Measures

Neck Disability Index (NDI) – 8%

Patient Specific Functional Scale (PSFS)

1. ability to lift extended arm with resistance (5lbs) - 6/10
2. ability to carry backpack (5-10lbs) - 3/10
3. ability to carry grocery bag without nerve symptoms – 4/10

Fear Avoidance Beliefs Questionnaire (FABQ) – 8
Generating Initial Hypotheses

Physical Examination

- Video Presentation
Pain Pattern Recognition


Treatment – Manual Therapy
Cervical

1st rib manipulation – inferomedial thrust
C2/C3 mobilization to restore flexion/ left side flexion/left rotation

OA mobilization/manipulation
Treatment – Manual Therapy
Thoracic

- PPIVM mobilization – extension/left side flexion/left rotation
- Supine distraction manipulation
- Passive accessory glides to restore ext
- Scapular muscle activation

Therapeutic Exercise Intervention Model

Therapeutic Exercise – Mobility

1. Train a neutral spinal posture from first treatment.
2. Train scapulothoracic and cervical/thoracic postures - actively correct posture and maintain for 10s. Practice is in sitting, standing (2-3 times an hour).

The combination of upper thoracic spine mobilization and mobility exercise demonstrated better overall short-term outcomes in craniovertebral angle (standing position), cervical extension, NPRS, NDI, and GRC compared with upper cervical spine mobilization and stabilization exercise in individuals with forward head posture. (Cho J et al 2017)

Cervical Stabilization Exercises

1. Train craniocervical flexor (CCF) activation and holding capacity - learn the correct movement and train to hold the contraction with and without feedback in progressively more difficult inner range positions.
2. Train the interaction of deep and superficial cervical flexors in movement patterning and functional tasks.
3. Train co-contraction of the deep cervical flexors and extensors.
4. Train strength and endurance of the cervical flexors / extensors.


Therapeutic Exercise - Axioscapular

1. Train scapular muscles in particular the upper/ middle/ lower trapezius and serratus anterior in both open and closed chain positions, with and without load and movement of the upper limb.
2. Train correct scapular posture.

Exercises can be progressed by closing the eyes, altering the support surface, adding concurrent voluntary movements, or increasing speed.

Therapeutic Exercise
Neuromuscular Re-education

Therapeutic Exercise
Neuro-mechanosensitivity

Sliders / Tensioners
Education / Pain Science Education (Ris et al 2016)

- Maintenance of good ergonomics
- Self-treatment techniques – stretching, diaphragmatic breathing and relaxation techniques
- Explanation of motor behaviour and the neurophysiological bases of pain and importance of patient’s involvement in treatment
- Goals and expectations of treatment

Take Home Messages

- When developing your assessment and treatment approach, clinical reasoning is fundamental
- Considering that the research evidence may be inconclusive regarding the effect of treatment to the thoracic spine on upper quadrant dysfunction; remember evidence-informed practice includes clinical expertise and the patient’s preferences
- Further research is needed examining the effectiveness of interventions and the proposed mechanisms involved in the Regional Interdependence Model (RIM)
References


Puentedura EL. The Thoracic Spine as a Special Region: Evidence for effectiveness and Risks associated with manipulating the thoracic spine & Pain Neuroscience Education NVMT Conference 2018


References


Heneghan NR, Davies SE, Puvertedura EO et al. Knowledge and pre-thoracic spine thrust manipulation examination: a survey of current practice in the UK. *JMMT* 2018 ahead of press.


